Permeation Issues Slides

Ben Hancock
California State Air Resources Board
PTSD MSAB Analysis Section
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WSPA Comments on ARB Ethanol Permeation Inventory Estimates

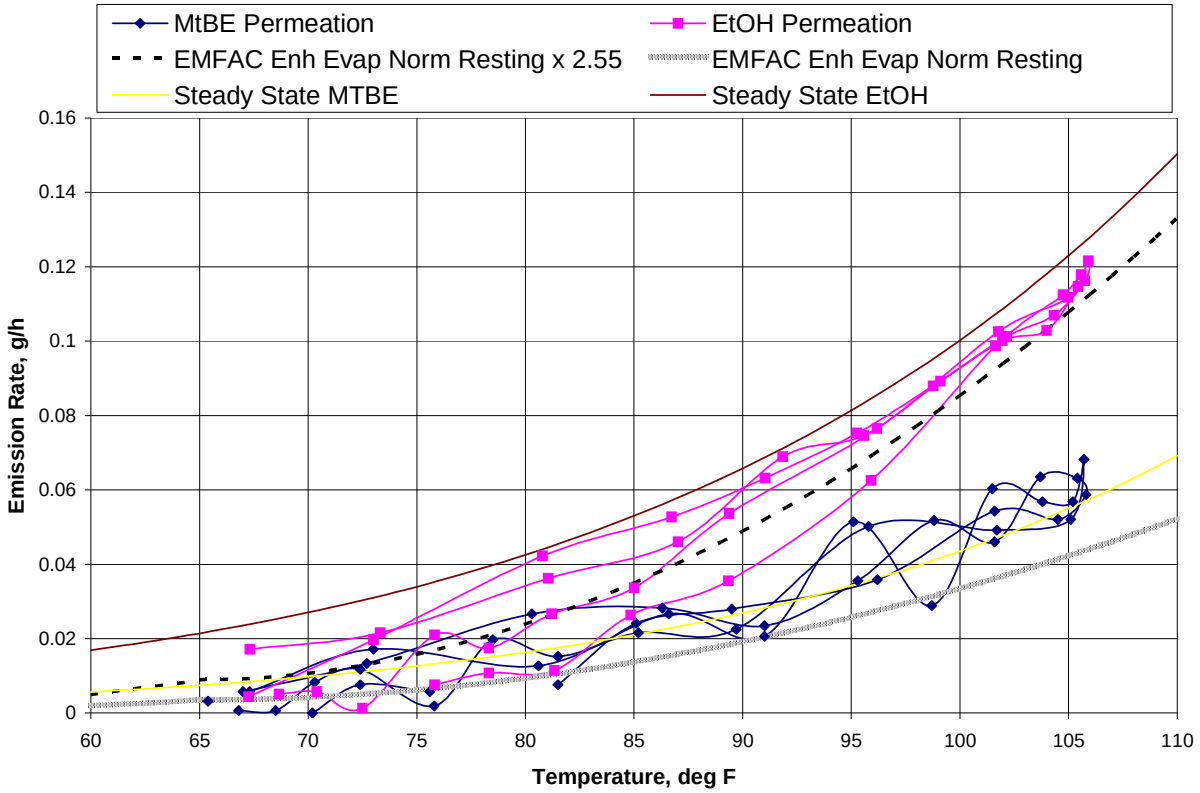
- WSPA Comments of April 2006
  - Assumption that 90% of resting losses are permeation, at all temperatures, for all vehicle classes and technologies
  - Augmentation ratio for liquid leakers is assumed to be 1.05. The data support 1.02. Difference is 1 tpd or 4-5%
  - Ambient temperatures are used when tank temperatures should be used
- WSPA Comments May 2006. CARB had to make a number of untested assumptions to model permeation
  - Augmentation Ratio
  - Permeation Contribution to each evaporative emissions process: diurnal, resting, hot soak, running
- Comments July 24, 2006
  - ARB method overpredicts the ethanol permeation increase at higher temperatures
  - If it overpredicts at higher temperatures, it probably overpredicts at lower temperatures (i.e. CA 8-h Ozone standard temps) as well

ARB Response: Liquid Leaker Augmentation

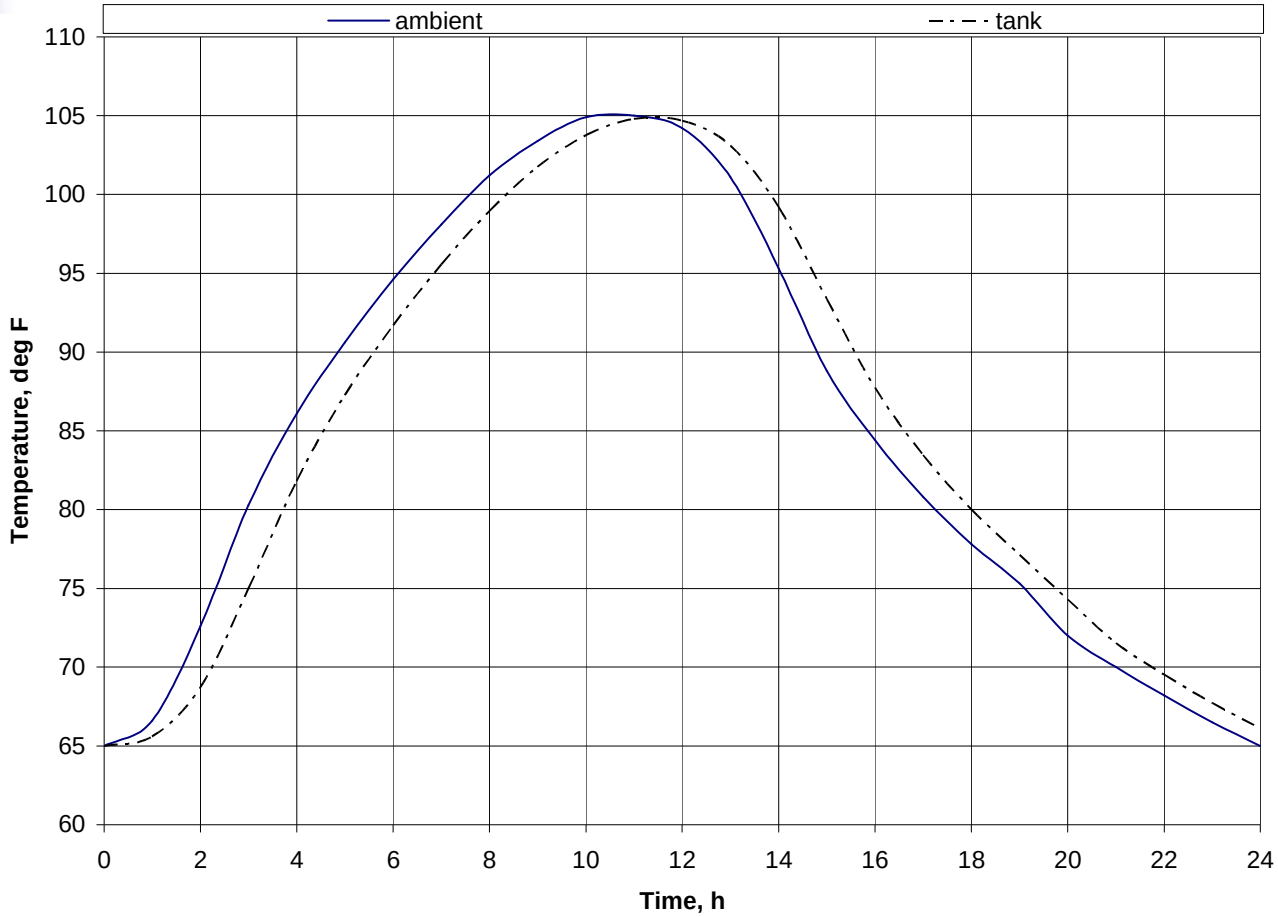
- We have no experimental basis
- Expect it to be between 1.0 and 1.2 (experimental value for moderates)
- Having absolute emissions be equal to moderates (1.1 g/d) is no more valid than the choice of 1.05. E65 avg moderates was 1.8 g/d. Highest rigs tested 2.5 and 2.7 g/d.
- At 1.05, about 1 tpd impact statewide.
- 1.05 is as good a number as any. We're staying with it.
- Until further testing comes up with a better value.

E65 Rig 2 Diurnal Results

- MTBE Permeation larger than Resting
- EtOH permeation larger than Augment x Resting

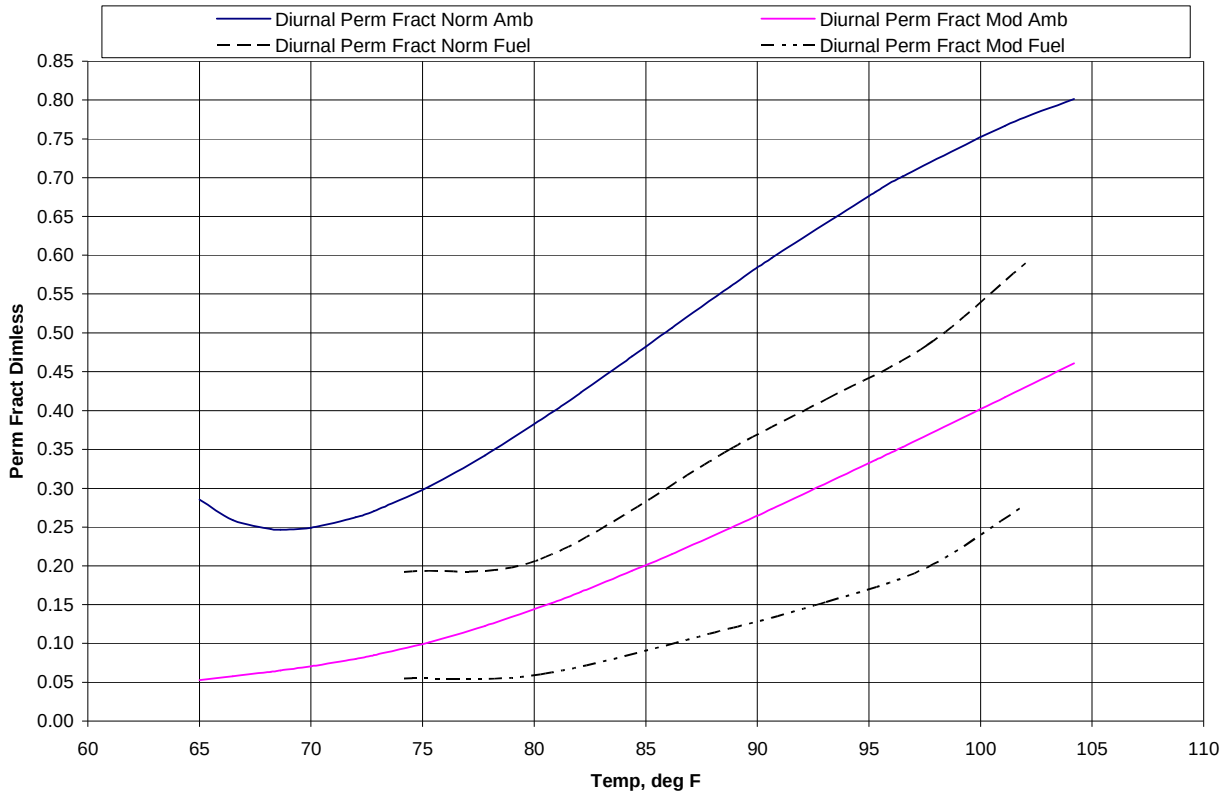


EPA 65-105 Ambient & Fuel Temps



Permeation Fractions, Enhanced Evap

- Correlating with fuel temperature results in much lower permeation fractions
- Permeation fraction is resting loss at fuel temp divided by diurnal loss at fuel temp



Effect of Correlating with Fuel Temps

- Permeation fractions are about cut in half
- Daily Effect is down about 20% for diurnal

Temperature Dependence Results Comparison

- Diurnal Permeation
- E65 Diurnals are 24-h basis. EMFAC diurnals exclude running time (about 1 h/d) and hot soak time (about 4 h/d). EMFAC permeation values shown are diurnal plus hot soak (D+HS).
- EMFAC and Steady-state extrapolation compare well for profiles in 80s.
- SCOS temp profile result is higher than E65 on 65-105.

		Diurnal	SCAB		
	Temp	Permeation	11.8		
Source	Range	Difference	M Vehicle		
	deg F	g/d/veh	TPD		
E65 hour-by-hour	65-105	1.5	19.5		
EMFAC 2002 Summer SCAB	62-83	0.8	10.0	*D+HS	
EMFAC SCAB Fed 8-h Summer	63-86	0.8	10.5	*D+HS	
EMFAC SCAB Cal 8-h	65-88	0.9	11.7	*D+HS	
EMFAC SCOS Episode SCAB	70-98	1.7	22.6	*D+HS	w/o Liq Lkrs
E65 SS	62-83	0.7	9.1		
E65 SS	63-86	0.8	10.4		
E65 SS	65-88	0.9	11.7		
E65 SS	70-98	1.4	18.2		

EMFAC Resting Temperature Dependence

- Ford Study found 8 to 12%/deg C.
- Normal Correlations are within range.
- Moderate Fuel-injected correlations are steeper.

EMFAC Tech Group	Resting Loss del T for 100% deg F	%/deg F	%/deg C
FI Zero Evap Norm	15.9	6.3	11.3
FI Enhanced Evap Normal	16.3	6.1	11.0
FI Pre-Enhanced Evap Normal	16.2	6.2	11.1
Carb 77+ Norm	17.0	5.9	10.6
Carb 77- Norm	18.8	5.3	9.6
FI Zero Evap Moderate	10.7	9.4	16.8
FI Enhanced Evap Moderate	10.6	9.4	17.0
FI Pre-Enhanced Evap Moderate	10.6	9.5	17.1
Carb 77+ Moderate	18.2	5.5	9.9
Carb 77- Moderate	19.1	5.2	9.4
Liquid Leaker	41.4	2.4	4.4

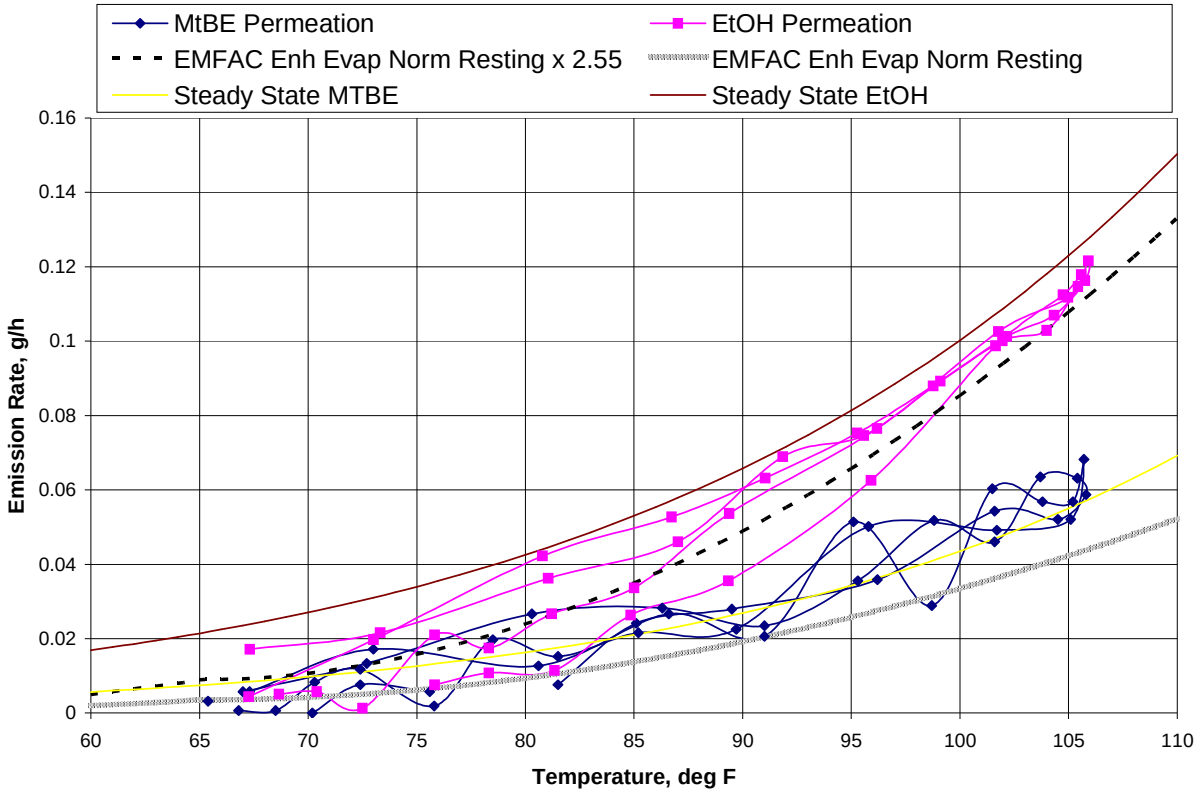
E65 Temperature Sensitivity

- Steady state results much flatter with temperature
- E65 hour by hour diurnal show same pattern as EMFAC

age y			Steady State Results MTBE dbl deg F	etoh dbl deg F	gaso dbl deg F	Hour-by-hour results (EtOH) Resting deg F	Diurnal HB deg F	
3	1	2001 Tacoma P/U	26.0	34.9	32.3	12.6	19.4	
4	2	2000 Odyssey Van	21.5	24.6	24.7	10.7	17.2	
5	3	1999 Corolla	23.7	24.5	20.0	10.8	18.1	
7	4	1997 T&C Van	25.4	24.3	35.3	14.7	17.8	
9	5	1995 Ranger P/U	26.4	24.4	24.9	13.7	17.9	
11	6	1993 Caprice	21.0	17.0	18.0	11.6	13.2	
13	7	1991 Accord	20.5	26.8	25.5	11.3	19.4	
15	8	1989 Taurus	26.8	26.4	30.7	15.9	21.1	
19	9	1985 Sentra	20.2	32.8	30.8	14.3	23.0	
26	10	1978 Cutlass	27.2	33.7	30.5	11.1	25.2	
		Population	24.1	25.0	24.8	13.8	19.1	15.0
		Hexane	56.1					
		Water	33.4					

E65 Rig 2 Diurnal Results

- Steady State rises strongly with temp
- Hourly and EMFAC correlation below steady state but steeper



Model Temperature Sensitivity

- Ford study correlated permeation to Clausius Clapeyron form. Found fractional change [(delta E/E)/delta T] of 0.08 to 0.12 per deg C (15 to 23 deg F for 100% change or doubling)
- E65 study found higher temperature slope for hour-by-hour results and lower slope for steady state results. Slopes were different for EtOH, MTBE, and non-oxygenated gasoline.
- EMFAC modeling method found no temperature dependence to augmentation, but used resting loss as a surrogate for permeation. Resting loss has higher temperature dependence than diurnal.
- EMFAC resting loss correlations have same or close temperature dependence to E65. Moderates have high dependence.
- Methods seem to compare pretty closely for temperature profiles peaking in high 80s. EMFAC method is much higher than E65 results in high 90s.